SHORTER ARTICLES AND DISCUSSION

MORE EYELESS CLADOCERA

JUST before a note appeared in *Science* (Vol. 53, pp. 462–463, May 13, 1921) concerning an eyeless cladoceran individual (a *Simocephalus exspinosus*), two additional eyeless daphnids occurred in another species of the experimental stock at the Station for Experimental Evolution. These were among offspring of some *Moina rectirostris* which were being subjected to crowding in a sex-control experiment (10 mothers in each 130 c.c. wide-mouthed bottle containing about 75 c.c. of culture medium). While these two eyeless young were released on successive days and possibly in separate bottles, they were in bottles which belonged to the same series and received the same treatment.

The precise identity of the mother of neither eyeless young could be determined (since there were 10 mothers producing parthenogenetic young in each bottle), but it is certain that the mothers were normal-eyed and were sisters, or came from mothers which were sisters. All of the mothers' collaterals, which were examined, approximately 250, had normal eyes. 302 other young, produced by the 10 mothers in the bottle in which the second of these eyeless appeared, were normal. In all about 5,953 young were microscopically examined—a few of which were presumably sisters of the eyeless individuals and the others of which were young from sisters of the mothers of the eyeless individuals. All were normal-eyed.

One of these eyeless individuals produced 5 broods, containing in all 66 young, all normals. The other produced 4 broods, containing 38 individuals, all normals. 841 offspring of daughters of the one eyeless, and 412 offspring of daughters of the other eyeless were found to have normal eyes. All examined among the collaterals of the eyeless individuals, 5,953 in all, and 1,357 direct first and second generation descendants of the eyeless mothers themselves—a total of 7,310—were normal. Hence despite the fact that there were two eyeless individuals produced by sisters (or by individuals whose mothers were sisters), while among many thousands of Cladocera previously seen under the microscope only a single similar individual had

been found, eyelessness in these individuals was clearly *not* inherited. The lack of inheritance in these *Moina rectirostris* would have been anticipated if due regard had earlier been given to a peculiar feature of the head of these eyeless individuals. This will be discussed in a later paragraph.

The next occurrence of eyeless Cladocera was in February, 1922, when seven eyeless *Moina macrocopa* were found among 147 young of the third brood from 10 mothers in a crowded bottle. The culture water in this bottle seemed rather cloudy, an appearance known frequently to be associated with unfavorable conditions which sometimes result in death to part or all of the Cladocera in such a bottle.[1] In the present case in addition to one eyeless male and 6 eyeless females among the 67 females and 80 males in the bottle, there were other abnormals—6 or 8 with abnormal eyes (pigment reduced or eye not completely formed) and perhaps an equal number with abnormal antennæ (certain segments missing, aborted or fused with others) and one male with an abnormal eye and an abnormal antennule. Some of the eyeless individuals and some with abnormal eyes had abnormal antennæ also. Others showed abnormality in only one feature. Since these abnormals appeared in a crowded bottle (10 mothers) it is impossible to know, but they probably did not come from a single mother. Among the next brood of young from the same mothers were a few with abnormal antennæ and slightly abnormal eyes. Subsequent young were normal.

Early attention to an interesting feature of the heads of these eyeless individuals removed any temptation to anticipate inheritance of eyelessness in these cases; and, as expected, all the numerous young examined from these eyeless individuals (and from the other abnormals as well) were normal. Since in these cases eyelessness was not hereditary some developmental accident would seem probably responsible for its occurrence. Indeed, it seems fairly evident, in view of the occurrence of other abnormalities in the same and other similar culture bottles, that these abnormalities were related to some unfavorable fac-

[1] In other cases such conditions of the culture medium were associated with pigmentless eyes in some of the newly released young. However, the pigment develops to its full amount in from one to five days after the young animals are released from the mother's brood chamber. Newly released young from the formerly pigmentless-eyed individuals have normally pigmented eyes from the first.

tor or factors in the environment, although nothing definite is known as to what these factors were.

A peculiar structural feature of the heads of the young eyeless individuals suggested the possible manner in which eyelessness came about in these cases. When young, the seven eyeless *Moina macrocopa* had on the anterior head margin a small nodule or excrescence which, though not so conspicuous at later stages, yet in most cases persisted through several moults. In each of these eyeless individuals the optic ganglion was reduced or lacking, and the margin of the head was readjusted to compensate for the reduced and missing organs. Substantially the same structural conditions were found with the two eyeless *Moina rectirostris,* absence or reduction of optic ganglia, the shortening of the head margin and the occurrence of a small bit of apparently necrotic material attached to the front of the head.[2]

It seems possible that this apparent exudate on the heads of the eyeless individuals really represented an aborted or necrotic portion of the embryo which included the primordium of the missing parts.[3]

The fourth occurrence of eyeless Cladocera (the eleventh eyeless individual seen) was June 26 in a crowded bottle of *Moina macrocopa.* In addition to the lack of eye and of optic ganglion, the brain proper was reduced in size. This animal was not examined until mature and an excrescence on the head, if present in the young animal, had by that time disappeared. This individual swam in small circles, although its swimming organs appeared entirely normal. It died after producing two broods (10 females and 12 males) of normal young.

The occurrences of eyeless Cladocera have included three species, eleven individuals and four different time periods. The last three occurrences, and probably the first one, were in crowded bottles, suggesting environmental factors as causative

[2] That this material was intimately associated with the head structures and really a part of the animal is attested by the fact that it persisted through ecdysis, whereas any material merely adhering to the external surface of the exoskeleton would be eliminated by ecdysis.

[3] A somewhat similar appearance in larvæ arising from centrifuged eggs of *Ambystoma punctatum* was presumably correlated with failure of development of the anterior part of the head. (Banta, A. M., and Gortner, R. A., "Accessory Appendages and Other Abnormalities Produced in Amphibian Larvæ through the Action of Centrifugal Force," *Jour. Exp. Zool., 18:* 433–446, pls. 1–3. 1915.)

agents. Those which lived to produce young gave rise exclusively to normal young, indicating that genetic changes were not responsible for the abnormal heads. However, in view of the known inheritance of eyelessness in cave arthropods and vertebrates and in *Drosophila melanogaster,* it seems of interest to examine each case of profound eye modification in crustaceans and elsewhere to gain information on the origin and inheritance of any possible mutation of this character.[4]

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CROSSING-OVER INVOLVING THREE SEX-LINKED GENES IN CHICKENS

IN the course of the last year several crosses of chickens carried out at the genetics station at Anikovo (near Moscow) have made it possible to observe crossing-over in this form. The genes "suke," "tuge" and "trage" were studied. The first, suke, retards the development of feathering in the chicks, so that at the age of 1 to 1.5 months they have very small tails. The development of the wings, too, is very slow. The genes trage and tuge together cause the well-known Plymouth Rock markings, trage causing the crossbarring, and tuge (not very visible in Plymouth Rocks, where it causes the contrasts in the markings) is the same gene as silver coloring, which was first reported by Hagedoorn in the Assendelver chickens. Later (1912) Davenport observed it in the cross of Dark Brahma × Brown Leghorn, where, however, on account of the absence of several other genes, tuge has very little expression—only as a whitish edge on the feathers.

The genes suke, tuge and trage are all present together in the Plymouth Rocks. The Russian Orloff chickens have none of these genes, a condition which may be expressed as asuke-atuge-atrage. All these genes are sex-linked, and therefore are transmitted with complete linkage from mother to son. The cross

[4] Since this manuscript went to the printer two more eyeless *Moina macrocopa* were found in a crowded bottle. These two with the last one mentioned above were the only eyeless occurring among approximately 33,000 individuals microscopically examined (in sex-control experiments) during three months. The facts, that of these three two occurred in the same bottle and that the character is not inherited, again indicate clearly enough that external, not internal, factors are responsible.